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Environmental Cleanup Office

FMC

April 4, 1997

Mr. Bill Adams
M/S HW-113
U.S. Environmental Protection Agency, Region 10
1200 Sixth Avenue
Seattle, WA 98101

Subject: Final Feasibility Study Report, FMC Subarea, Eastern Michaud Flats Site

Dear Mr. Adams:

Enclosed please find five (5) copies of the Final Feasibility Study (FS) Report, FMC Subarea, Eastern Michaud Flats Site. The final FS report addresses all of the previous EPA comments including those in the EPA letter dated March 28, 1997. A summary of the revisions in response to the March 28 letter is provided on the attached Responses to Final EPA Comments on the FS Report, FMC Subarea.

Please feel free to contact me at (208) 236-8658 should you have questions regarding this information.

Very truly yours,

Rob J Hartman

Rob J. Hartman
FMC Corporation
Phophorus Chemicals Division

Enclosure

cc: Susan Hanson, Shoshone-Bannock Tribes
Gordon Brown, Idaho Department of Environmental Quality
Rob Hanson, Idaho Department of Environmental Quality
Dhroov Shivjiani, Ecology and Environment
Carl Stineman, Ecology and Environment

Responses to Final EPA Comments on the FS Report, FMC Subarea

<u>FS Report Section 1-6 for the FMC Subarea</u>

Comment 1 and 2. The third sentence, top paragraph, page 1-35 has been deleted. The fifth and sixth bullet, page 2-6 have been deleted and replaced with the following bullet (modified per telephone conversation between Bill Adams and Jim Sieverson/Rob Hartman on March 31, 1997):

- Cadmium was designated as a COPC in Portnuef River delta sediment because it was elevated at this location compared with sediment from the Snake River delta and Portnuef River upstream from the facilities. However, EPA's baseline ecological risk assessment concluded that the majority of cadmium is strongly bound to sediment and, thus, is not in a bioavailable form.

Comment 3. The proposed text change has been made.

Comments 4 and 5. Previous response acceptable.

Comment 6. Per Comment 3, the proposed text change has been made.

Comment 7. Comment does not require revision to the FS.

Comment 8. Previous response acceptable.

Comment 9. The third paragraph under section 2.4.3 on page 2-102 has been revised. The following text has been added as the last two sentences of the paragraph:

> Cadmium concentrations in the Portnuef River delta were elevated in comparison to upstream Portnuef River and Snake River delta sediment samples. EPA's baseline ecological risk assessment concluded that the majority of cadmium is strongly bound to sediment and, thus, is not in a bioavailable form.

Comment 10. Per telephone conversation between Bill Adams and Jim Sieverson/Rob Hartman on March 31, 1997, the revised sentence (March 4, 1997 Company Response) has been retained in the FS.

Comment 11. The last paragraph on page 2-104 has been replaced with the same text change as for Comment 3.

<u>FS Report Section 7 and 8 for the FMC Subarea</u>

General Comment and Comments 1-2. Comment does not require revision to the FS.

Comment 3 and February 10, 1997 letter: The last 2 paragraphs on page 7-71 and the first full paragraph on page 7-72, and Table 8-1 have been revised to replace "70+ years" to "several decades."

Attachment A to this response provides a supplemental evaluation of the observed conditions related to old ponds and impacts to groundwater over time that supports FMC's position that groundwater extraction will not significantly accelerate the time frame for groundwater restoration.

Comment 4. Comment does not require revision to the FS. The dose is related to the configuration of source and shield as inputs to the model; however, FMC did not have time to prepare a complete answer to your question. FMC's consultant is reviewing the various configuration inputs and calculated doses and will provide an answer to EPA's question shortly.

Comment 5. Previous response acceptable.

Comment 6. The FS report does not include any statements regarding either the adequacy of the Pond 8S study or that the study is or is not consistent with EPA's comments on the study. In FMC's previous response (March 7, 1997 letter), the Company proposed to revise the time to cleanup groundwater from "70+" to "30 to 70+ years" to recognize that a range of time is a more realistic representation of migration rates of COPCs from the old unlined ponds and in groundwater. After further discussions with EPA, the FS has been revised to refer to the time to cleanup as "several decades" as discussed in the response to Comment 3 above.

Comment 7. Comment does not require revision to the FS.

Comment 8. Previous response acceptable.

Comment 9. The attached document "FMC Subarea - Appendix A, Attachment 1" provides a preliminary design and cost estimate for extending the lined (flexible membrane liner system) portion of the railroad swale. The document has been appended to the FS Report as Attachment 1 to Appendix A.

Comment 10. Per telephone conversation between Bill Adams and Rob Hartman on April 2, 1997, Table 7.1-1 (first sheet) has been revised to indicated that the WQC is Appropriate and Relevant (the Appropriate and Relevant column has been changed to "Yes" and "Not an ARAR." has been deleted from the Comment column).

Comments 11-26. Previous responses acceptable.

Attachment A to FMC's response to EPA's comment 3 and February 10, 1997 letter on FS Section 7 and 8 - FMC Subarea from EPA comments dated March 28, 1997

1.0 INTRODUCTION

EPA has requested that FMC provide an explanation as to why a pump and treat system will not reduce the time to cleanup for various inorganic constituents in the shallow aquifer beneath the FMC subarea at the Eastern Michaud Flats Site.

A characterization of old and recent releases at FMC was presented to the EPA Region 10 RCRA Branch (Bechtel, 1997), and the data utilized for that characterization also provides the foundation for FMC's position regarding the inability of a groundwater pump and treat system to significantly accelerate groundwater cleanup.

Data discussed in this report were previously submitted to EPA in the EMF Remedial Investigation Report (Bechtel, 1996) and with FMC annual Interim Status Groundwater Monitoring Assessment Reports (FMC, 1993, 1994, 1995, 1996, 1997). The discussion herein is complementary to the site model of fate and transport in the RI report (Bechtel, 1996).

2.0 Summary

The sources of various constituents FMC subarea groundwater are residual materials in the vadose zone and within the fine-grained saturated zone. Groundwater chemistry data indicate that the most mobile, conservative solutes have largely migrated through the vadose zone-aquifer system and that the remaining solutes detected in the monitoring network occur as a result of slower release mechanisms. For example, it appears that orthophosphate and arsenic are released from residual pond sludges as the elemental phosphorus in these sludges slowly oxidizes. The ratio of potassium and arsenic in wells monitoring old releases is quite different than the ratio in wells at recent releases, indicating that physical dewatering of the vadose zone and fine-grained aquitard is not the sole cause of elevated constituents.

Because the source of arsenic and other constituents is a slow releasing source, unaffected by groundwater flow rates within the aquifer, a groundwater pump-and-treat system will not reduce the time to achieve groundwater restoration within the FMC subarea.

3.0 Hydrogeology

The FMC old ponds are located in the southwestern and central portions of the FMC subarea (Figure 1). Most old ponds are located within a transition zone between the Bannock Range to the south and the Michaud Flats to the north. As a result, alluvial lithologic units originating from the Bannock Range and comprised of volcanic and quartzitic gravel and fine-grained materials interfinger with American Falls Lake Bed and Michaud Gravel that were deposited in the valley. Lateral facies changes occur within these lithologic units.

The geology consists of a vadose zone with up to 40 feet of loess and fine-grained colluvial material overlying an unsaturated gravel. This gravel overlies another fine-grained unit, the silt and clay aquitard. The groundwater table occurs between 70 to 100 feet below ground surface, within the aquitard. The aquitard overlies a sand and gravel unit, which is the uppermost aquifer. This aquifer is about 10 to 20 feet thick in most places. It is also locally discontinuous, which is typical of the alluvial depositional environments between the Bannock Range and Michaud Flats.

4.0 Effects of Pump-and-Treat on Sources within FMC Subarea

A groundwater extraction system would draw groundwater from the uppermost aquifer within the FMC subarea. An extraction system located near the old ponds and drawing groundwater from the uppermost aquifer would have no effect on the rate of arsenic and orthophosphate migration from the vadose zone into the saturated zone.

This is due to the fact that flow and migration through the vadose zone are independent of the fluxes of groundwater in the saturated zone. Flow and migration of chemicals emanating from vadose zone sources are controlled by dissolved chemical concentrations in water that infiltrates through the vadose zone and the amount of water available for deep percolation. Vadose zone gradients are typically a constant downward gradient of 1.0, with flow occurring under partially saturated conditions. Because flow velocities (and consequently water fluxes) in the vadose zone are influenced by factors not related to the aquifer fluxes, vadose zone sources will not be removed any more quickly by use of a pump-and-treat system as compared to natural attenuation.

It is also unlikely that pumping groundwater from the downgradient areas of the old ponds would increase the desorption rates of site-related constituents bound to fine-grained materials within the saturated zone. Desorption of these bound chemicals is a diffusion-limited process, which means that the rate of desorption is independent of the rate at which groundwater flushes through an affected area.

RI data indicate the vadose zone soils are relatively impermeable (see Table 2, Appendix K of RI Report for complete dataset), with typical values of 10^{-5} to 10^{-6} cm/s. This relative impermeability in the vadose zone silts and clays indicates that the physical dewatering and associated transport of constituents from the vadose zone beneath former unlined ponds will continue for a very long time. For example, the flow velocity of water under a unit gradient with a saturated hydraulic conductivity of 1×10^{-5} cm/s is about 10 feet per year. As the vadose zone soils dewater, the hydraulic conductivity decreases (this is effective hydraulic conductivity), slowing down the migration of fluids through the vadose zone even more. As soil moisture decreases, the flow velocity is reduced and water migrating from the base of the old ponds through 70 to 100 feet of vadose zone material will require significantly more time to reach the aquifer. Pumping from the uppermost aquifer will have no effect on these travel times or the concentrations of arsenic and other constituents contained in the infiltrating water.

Regarding the constituents contained in the saturated fine-grained aquitard, pumping from the underlying aquifer would only marginally increase the rate at which these constituents migrate from the aquitard to the pumping well. Pumping a sufficient amount from the uppermost aquifer would induce a downward flow potential between the aquifer and the aquitard, thus drawing out the water from the aquitard at a slightly greater rate. However, physically dewatering the aquitard will not decrease the time to cleanup because the constituents are released by desorption or diffusion limited processes.

5.0 Observed Impacts from Old Ponds

This section discusses the impacts on groundwater that the old ponds continue to have in the FMC subarea. These impacts are discussed in the context of what is known regarding old pond history, fate and transport, and the chemical characteristics of pond water (source characteristics).

Since the FMC facility began operation, numerous storage/disposal ponds have existed at the site. After the installation of slurry systems for precipitators in 1954-1955, a series of unlined disposal ponds were constructed throughout the west-central portion of the facility. These ponds were used to store both "phossy" water from the phosphorus loading dock area and the precipitator slurry from the furnace operations. As one pond filled, another was brought into service. A total of sixteen unlined ponds were developed for this purpose. The construction of unlined ponds continued until lined ponds were constructed beginning in 1976. All ponds constructed since 1976 are lined. Most of the unlined ponds were dewatered and covered or excavated to accommodate new lined ponds by 1981. The last unlined pond, Pond 8S, was filled, dewatered and capped (temporary pursuant to a final cap) in 1994.

Fate and Transport Summary

The fate and transport of chemicals in the environment was characterized through the analysis of thousands of liquid and solid waste, soil, ore, groundwater, and surface water samples. Most of this work was performed as part of the Eastern Michaud Flats Superfund Site Remedial Investigation (Bechtel, 1995) and under the FMC Facility Assessment (FMC, 1991). Quarterly groundwater monitoring data are reviewed throughout the year, and annually evaluated and reported to EPA (FMC, 1993, 1994, 1995, 1996, 1997).

Many metals, common ions, phosphorus, and some other inorganic chemicals are present in solid and liquid wastes that were placed in the old unlined ponds. Therefore, the wastes are potential sources for numerous chemicals. The data indicate that these chemicals can be classified as follows:

Class 1. Immobile - (examples are cadmium, chromium, and nickel))

Class 2. Mobile through vadose zone, immobile in saturated zone (examples are zinc, cobalt, vanadium)

Class 3. Mobile through vadose zone, attenuated in saturated zone (examples are fluoride and ammonia)

Class 4. Highly Mobile/Conservative solutes (examples are potassium and chloride)

Chemical Characteristics of Pond Water

The chemical characteristics of pond waters were evaluated as part of the remedial investigation. These pond waters are comparable to the water that was contained in and released from the old ponds. Analytical results from pond water grab samples are shown in Table 1. The source for the various ions and metals in the pond water is the process solids in the slurry water from which some metals and ions are dissolved. In addition, some of the pond water is recycled to various points in the process and this recycling causes more concentration of solutes by evaporation.

In comparison with background groundwater, pond water has high concentrations of potassium, chloride, magnesium, calcium, and sodium (common ions), the highest being potassium. The pond water also contains comparatively high concentrations of cadmium, vanadium, chromium, and other metals. For example, pond water samples contained up to 1.66 mg/l of cadmium, whereas background groundwater typically contained less than 0.005 mg/l cadmium (Table 1).

Fluoride and orthophosphate are found in very high concentrations in pond water. Arsenic concentrations in pond water are elevated with respect to background groundwater, but typical pond water concentrations are less than 1.0 mg/l.

Characterization of old and recent release - Groundwater data

Wells 104, 150, 152, 155, 156, and 157 monitor the shallow aquifer in an area affected by a recent release from former Pond 8S (Table 2). This pond was backfilled and dewatered during 1994 and is capped (temporary pursuant to final closure cap). These wells contain, on average, the highest concentrations of orthophosphate, fluoride, and potassium compared to the other shallow monitoring wells located within the southwest FMC area. The chemical concentrations in wells near Pond 8S have not decreased since dewatering and temporary capping occurred in 1994, indicating that the effects of pond closure and dewatering are not immediate in terms of groundwater quality.

Wells 170 and 116 monitor two old ponds that were closed in 1981 and 1982. Arsenic, orthophosphate, and fluoride concentrations remain elevated with respect to background groundwater concentrations (Table 2). However, concentrations of these constituents are much lower when compared to the wells near former Pond 8S.

Figure 2 illustrates the potassium concentrations in the wells from former Pond 8S area, wells 170 and 116, and the other RCRA wells. The potassium concentrations from aquifer groundwater at former Pond 8S are over 100 times the background concentrations. Old releases, as characterized by wells 170, 116, and other shallow wells, have potassium concentrations that are 1 to 10 times the background concentrations.

Fluoride concentrations were also plotted in a similar chart (Figure 3). It is apparent that, when compared to potassium, the fluoride concentrations decrease more rapidly from the pond water to the aquifer water and from recent releases to old releases. Mean fluoride concentrations in shallow wells (except 168) plot below the fluoride levels that characterize an old release. Fluoride concentrations in Pond 8S area wells show fluoride concentrations associated with a recent release are on the order of 8 to 10 times background levels. Old releases have concentrations up to 1.5 times the background levels.

Orthophosphate and arsenic do not follow this pattern quite as markedly (Figures 4 and 5), but this is probably because arsenic and orthophosphate are/were released from pond sludges as the sludges were exposed to air and the elemental phosphorus oxidized. In other words, old pond sludges continue to be a source of orthophosphate and arsenic whereas the bulk of the fluoride and potassium have already migrated through the vadose zone and aquifer system. This may explain why arsenic and orthophosphate are elevated in well 115 (and others), but fluoride and potassium are at or below background levels.

6.0 Residual Source Materials

Residual constituents associated with the old unlined ponds at FMC are released to the groundwater underflowing these old ponds by reversible desorption processes and by physicochemical changes occurring within the residual sludges, vadose zone, and fine-grained aquitard overlying the uppermost aquifer.

After a pond has been closed and dewatered for approximately 15 years, physical dewatering of residual pond fluids from the vadose zone and aquitard is a minor source of constituents. Addition of potassium to the aquifer by physical dewatering of pond waters from overlying strata would be indicated by potassium concentrations in excess of background concentrations, and in many shallow monitoring wells, this is not the case. In numerous shallow monitoring wells, the potassium concentrations are at background, or 1.5 times the background levels.

In the same set of shallow monitoring wells (wells used in the RCRA groundwater monitoring program), arsenic and orthophosphate concentrations are greater than 10 times the background concentrations, indicating a different release mechanism(s) for these constituents.

Pond sludges contain some elemental phosphorus, and trace amounts of arsenic substitute for phosphorus atoms in the P_4 tetrahedra. As the sludges dewater, they are slowly oxidized. As oxidation occurs, the elemental phosphorus (and associated arsenic) is ultimately converted to orthophosphate and arsenate. There are intermediate oxidation states that occur, but the orthophosphate and arsenate appear to be the most mobile (SII, 1994).

The sludges are not the only source of orthophosphate and arsenate. Phosphorus migrated into the soils underlying the former unlined ponds under the influence of the sustained hydraulic head exerted by the pond liquids. Arsenic and phosphorus were transported into the vadose zone by these infiltrating pond waters in a reduced state, similar to the negative Eh conditions observed around former Pond 8S. Under these conditions, it is likely that phosphorus and arsenic were adsorbed to soil grains in the vadose zone and the silt aquitard. After the old ponds were closed and reducing conditions slowly changed to oxidizing conditions, the adsorbed phosphorus and arsenic are being released in solution to the aquifer in their oxidized states.

These conditions can be better understood through examination of soil and groundwater data beneath former unlined ponds 1E, 5E, and 6E. Figure 6 displays the location of these former ponds and associated soil and groundwater sampling points. The distribution of phosphorus beneath former unlined ponds 1E, 5E, and 6E is illustrated in Figures 7 through 9, respectively. Conditions beneath these former ponds are displayed because there were a number of deep soil borings advanced through their footprints during the remedial investigation. As all the ponds were operated similarly, the other old unlined ponds are expected to have similar subsurface characteristics.

Figures 7 through 9 also illustrate the texture of soils encountered during advancement of these borings, as well as the screened intervals of nearby groundwater monitoring wells. The concentration of total phosphorus, orthophosphate (PO_4 as P), and potassium detected in soil samples obtained from these borings is also plotted on Figures 7 through 9, as are the mean concentrations of these constituents in groundwater samples collected during the remedial investigation from the associated monitoring wells.

Review of Figures 7 through 9 shows that total phosphorus has migrated into the silts of the vadose zone and aquitard. The hydraulic conductivity of these soils — characterized during the remedial investigation — has typical values from approximately 1×10^{-5} cm/sec to 1×10^{-6} cm/sec (see Appendix K of the EMF Remedial Investigation Report, BEI 1996). In contrast, the hydraulic conductivity of the sands and gravels of the uppermost aquifer — also reported in Appendix K of BEI 1996 — ranges from approximately 1×10^{-1} cm/sec to 7×10^{-4} cm/sec.

Comparison of total phosphorus and orthophosphate concentrations in these soil samples provides insight into the valence state of phosphorus. The comparatively lower orthophosphate concentrations, when compared with total (or elemental) phosphorus concentrations, in these low-permeability soils indicates the phosphorus has not completely oxidized. Given the low permeability of these soils, and the depth below ground surface to which the phosphorus has migrated, it is likely that this oxidation process is proceeding slowly.

The mechanism of reversible desorption may also be at work within the saturated zone as well. When a fluid with high solute concentrations migrates through rock and sediments, some solutes are adsorbed onto mineral grain surfaces. Adsorption itself can be induced by many different mechanism, including ion exchange and Van der Waals forces. When a high concentration fluid ceases to flow through a media, and low concentration groundwater begins flowing through the same rock and sediment, the adsorbed ions are released back into solution due to a reversal in concentration gradients. As discussed earlier, it appears that potassium migration is not influenced by adsorption, whereas arsenic, phosphorus, and other constituents are influenced to varying degrees.

7.0 Conclusion

A pump and treat alternative at FMC will not accelerate groundwater restoration because the constituent sources are not affected by the hydraulic changes induced by pump and treat systems. The sources lie within the vadose zone and fine-grained aquitard that are largely physically independent from the hydraulic conditions in the aquifer. In addition, the long-term release of constituents to the aquifer is controlled by chemical reactions, such as oxidation and desorption, more so than by physical processes such as infiltration and groundwater flow rates. These factors demonstrate that a pump and treat system would not be effective in reducing the time to cleanup.

References

Bechtel Environmental, Inc., August 1995, "Remedial Investigation Report for the Eastern Michaud Flats Site".

Bechtel Environmental, Inc., March 1997, "Supplemental groundwater information for the FMC Elemental Phosphorus Plant", Pocatello, Idaho.

FMC Corporation, 1991, "FMC Facility Assessment" Pocatello, Idaho.

FMC Corporation, August 1993, "RCRA Interim Status Groundwater Monitoring Assessment" Pocatello, Idaho.

FMC Corporation, February 1994, "RCRA Interim Status 1993 Groundwater Monitoring Assessment" Pocatello, Idaho.

FMC Corporation, February 1995, "RCRA Interim Status 1994 Groundwater Monitoring Assessment" Pocatello, Idaho.

FMC Corporation, February 1996, "RCRA Interim Status 1995 Groundwater Monitoring Assessment" Pocatello, Idaho.

FMC Corporation, February 1997, "RCRA Interim Status 1996 Groundwater Monitoring Assessment" Pocatello, Idaho.

Sciences International, Inc., 1994, "Solute Geochemistry of Eastern Michaud Flats Aquifer", Pocatello, Idaho

Table 1
Pond Water Chemistry vs. Background Groundwater Chemistry

		Discharge to Pond 8E	Discharge to Phase IV Ponds	Pond 8S Water	Pond 8S Water (Duplicate)	Bannock Range*	Michaud Flats*
COMMON IONS							
Alkalinity, Bicarbonate	(mg/L)	4420	1640	5130	5150	171	198
Calcium	(mg/L)	114	30.4	219	213	68.7	97.7
Chloride	(mg/L)	740	307	1120	874	52.42	192.9
Magnesium	(mg/L)	19.6	13.3	24.6	24.7	19.2	33.59
Potassium	**(mg/L)**	**9890**	**2890**	**8780**	**8610**	**10.52**	**12.7**
Sodium	(mg/L)	1449	598	1220	1170	27.53	74.3
Sulfate	(mg/L)	33	2	23	22	43.4	72.6
SELECTED METALS							
Arsenic	**(mg/L)**	**0.049**	**0.145**	**0.653**	**0.059**	**0.018**	**0.015**
Cadmium	(mg/L)	1.66	0.0236	1.86	1.77	0.005	0.005
Chromium	(mg/L)	2.03	0.41	2.24	2.18	0.011	0.0114
Cobalt	(mg/L)	0.09	0.034	0.05	0.05	0.011	0.0145
Lithium	(mg/L)	1.66	0.537	0.91	0.92	0.017	0.061
Manganese	(mg/L)	11.6	0.204	1.39	1.38	0.020	0.052
Nickel	(mg/L)	2.45	0.007	0.11	0.12	0.02	0.020
Selenium	(mg/L)	0.207	0.229	0.016	0.026	0.0055	0.0057
Vanadium	(mg/L)	15.62	0.37	1.34	1.59	0.100	0.075
Zinc	(mg/L)	5210	41.8	342	341	0.170	0.050
NUTRIENTS AND FLUORIDE							
Ammonia (NH_3 as N)	(mg/L)	39.6	29.7	63.6	61.6	0.5	0.5
Fluoride	**(mg/L)**	**1510**	**436**	**1180**	**1150**	**0.6**	**0.8**
Nitrate (NO_3 as N)	(mg/L)	0.39	0.6	0.07	0.08	1.6	5.52
Orthophosphate (PO_4 as P)	**(mg/L)**	**1360**	**782**	**3670**	**3670**	**0.13**	**0.06**
PHYSICAL PARAMETERS							
pH		10.47	7.99	7.38	7.38	7.29 to 7.70	7.37 to 8.37
Redox	(millivolts)					0 to 170	44 to 122

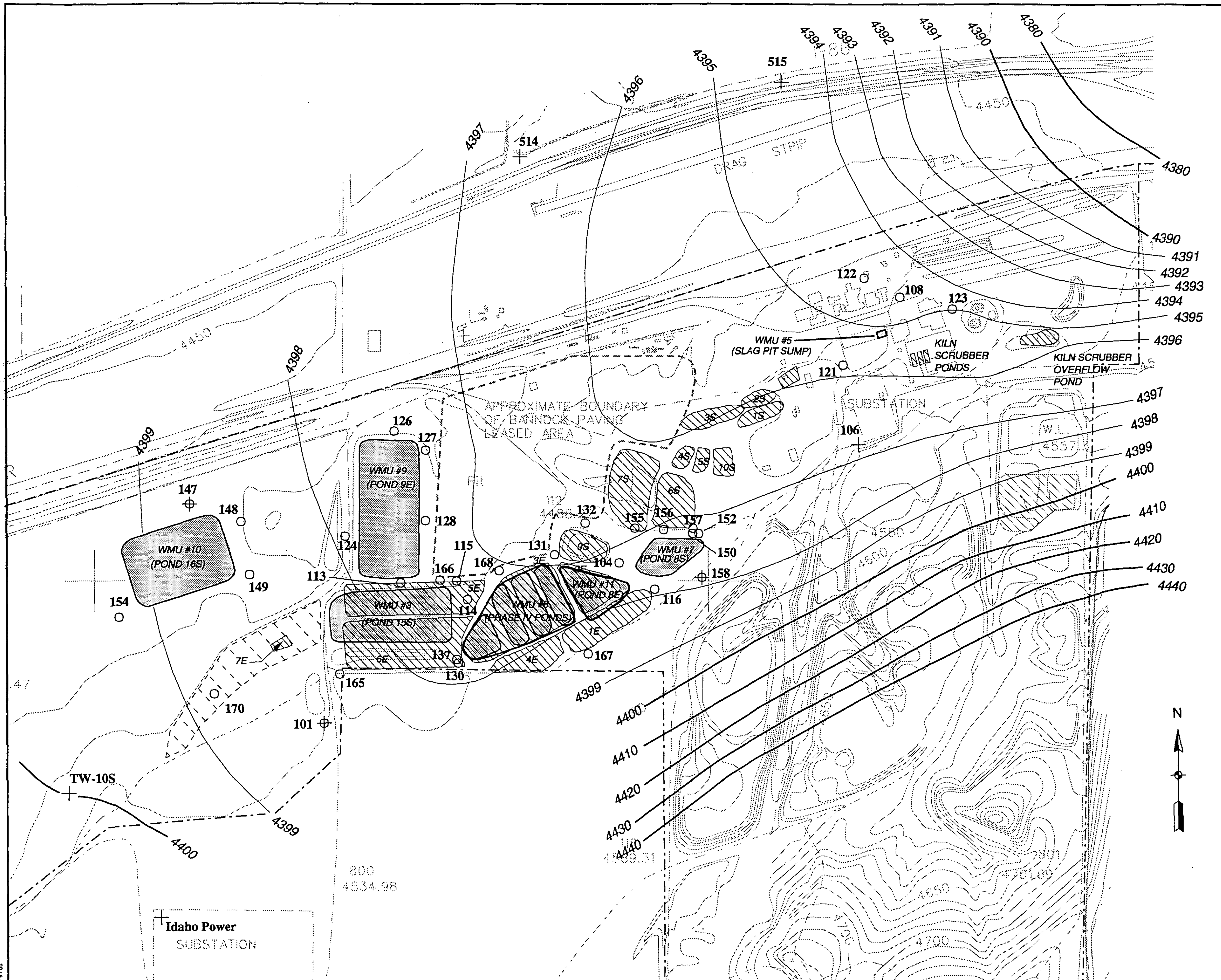
* Background groundwater chemistry was defined in the Eastern Michaud Flats RI Report.
The values used on this table are 95% upper confidence limits about the mean values calculated for wells 514, 515, TW-10S, 101, 102, and 147 for Michaud Flats groundwater and wells 106, 158, 301, Kinport (Idaho Power), 305, and PEI-1 for Bannock Range groundwater.

U = Not Detected. Value represents detection limit.

Table 2
Recent Release vs. Old Release

		Recent Release						Old Release		Background Groundwater	
		Well 104	Well 150	Well 152	Well 155	Well 156	Well 157	Well 170	Well 116	Bannock Range	Michaud Flats
Arsenic	**(mg/L)**	**0.092**	**0.204**	**0.159**	**0.328**	**0.340**	**0.208**	**0.033**	**0.074**	0.018	0.015
Potassium	**(mg/L)**	**268.5**	**1451**	**1169**	**487**	**2561**	**1264**	**63.1**	**162**	10.5	12.7
Fluoride	**(mg/L)**	**5.73**	**13.5**	**9.5**	**0.21**	**0.35**	**9.0**	**1.61**	**0.84**	0.6	0.8
Orthophosphate (PO_4 as P)	**(mg/L)**	**9.63**	**478**	**299**	**52**	**373**	**287**	**0.62**	**2.38**	0.06	0.13

* Background groundwater chemistry was defined in the Eastern Michaud Flats RI Report.
The values used on this table are 95% upper confidence limits about the mean values calculated for wells 514, 515, TW-10S, 101, 102, and 147 for Michaud Flats groundwater and
wells 106, 158, 301, Kinport (Idaho Power), 305, and PEI-1 for Bannock Range groundwater.



LEGEND

- Representative Well
- Monitoring Well Location
- Former Unlined Ponds and Waste Management Units
- WMU #7 (POND 8S) — RCRA Hazardous Waste Management Unit Location, (WMU). Colors Distinguish Individual Ponds.
- 4399 — Groundwater Elevation Contour (Contour Interval = 1 foot) during March 1995 Sampling Event
- 4410 — Groundwater Elevation Contour (Contour Interval = 10 foot) during March 1995 Sampling Event

NOTES:

1) Outer boundary of former unlined Pond 7E shows maximum extent of intermittent ponded overflow water.

0 800 1600 FEET

0 100 200 300 METERS

BECHTEL ENVIRONMENTAL, INC.	
SAN FRANCISCO	
FMC CORPORATION POCATELLO, IDAHO	
HAZARDOUS WASTE MANAGEMENT UNITS, FORMER PONDS, ASSOCIATED RCRA WELLS, AND REPRESENTATIVE WELLS	

JOB No.	DRAWING No.	REV.
20906	FIGURE 1	

FIGURE 2
Potassium Concentrations vs. Time (Approximate Decay Curve)

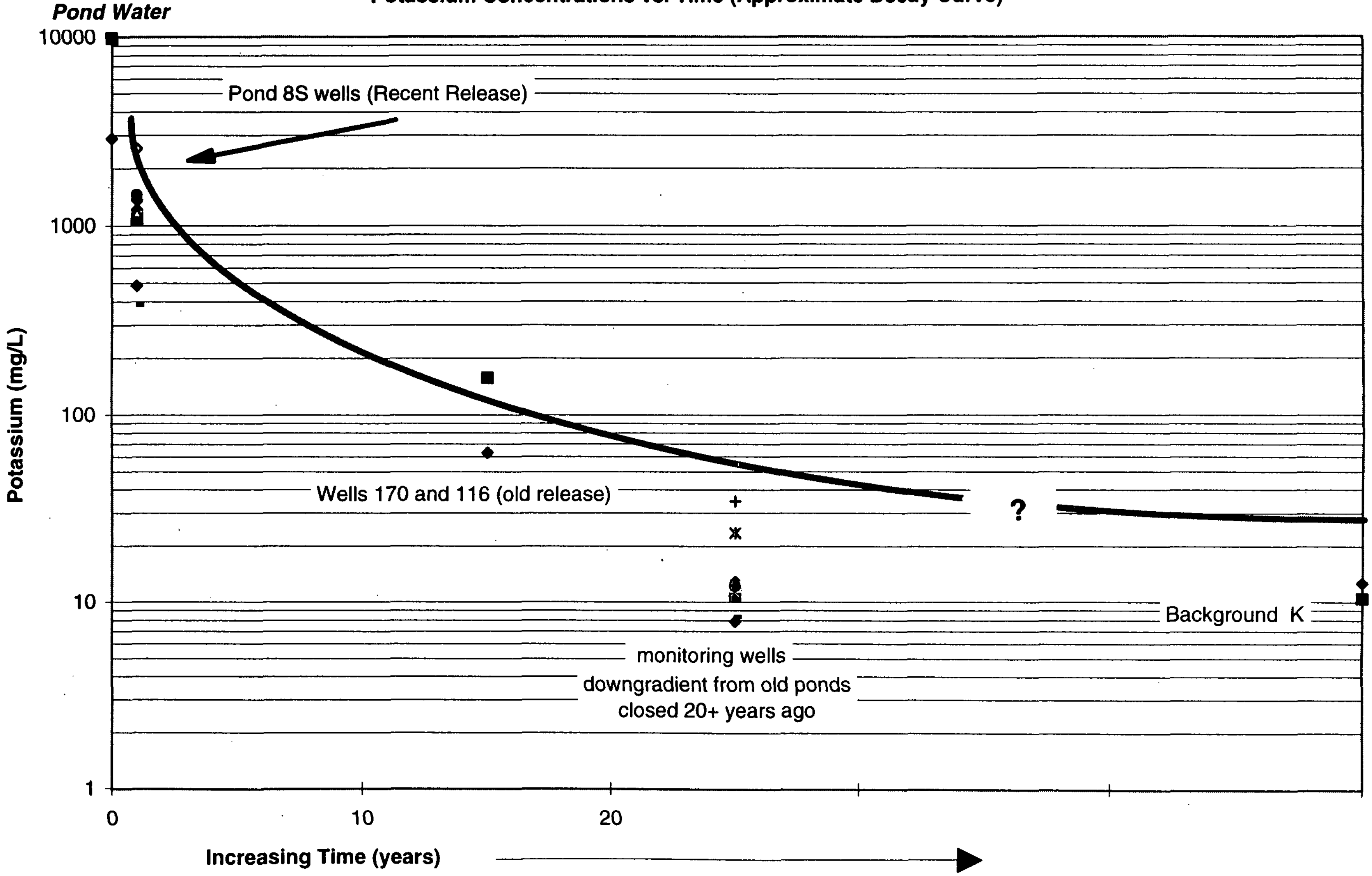


FIGURE 3
Fluoride Concentrations vs. Time (Approximated Decay Curve)

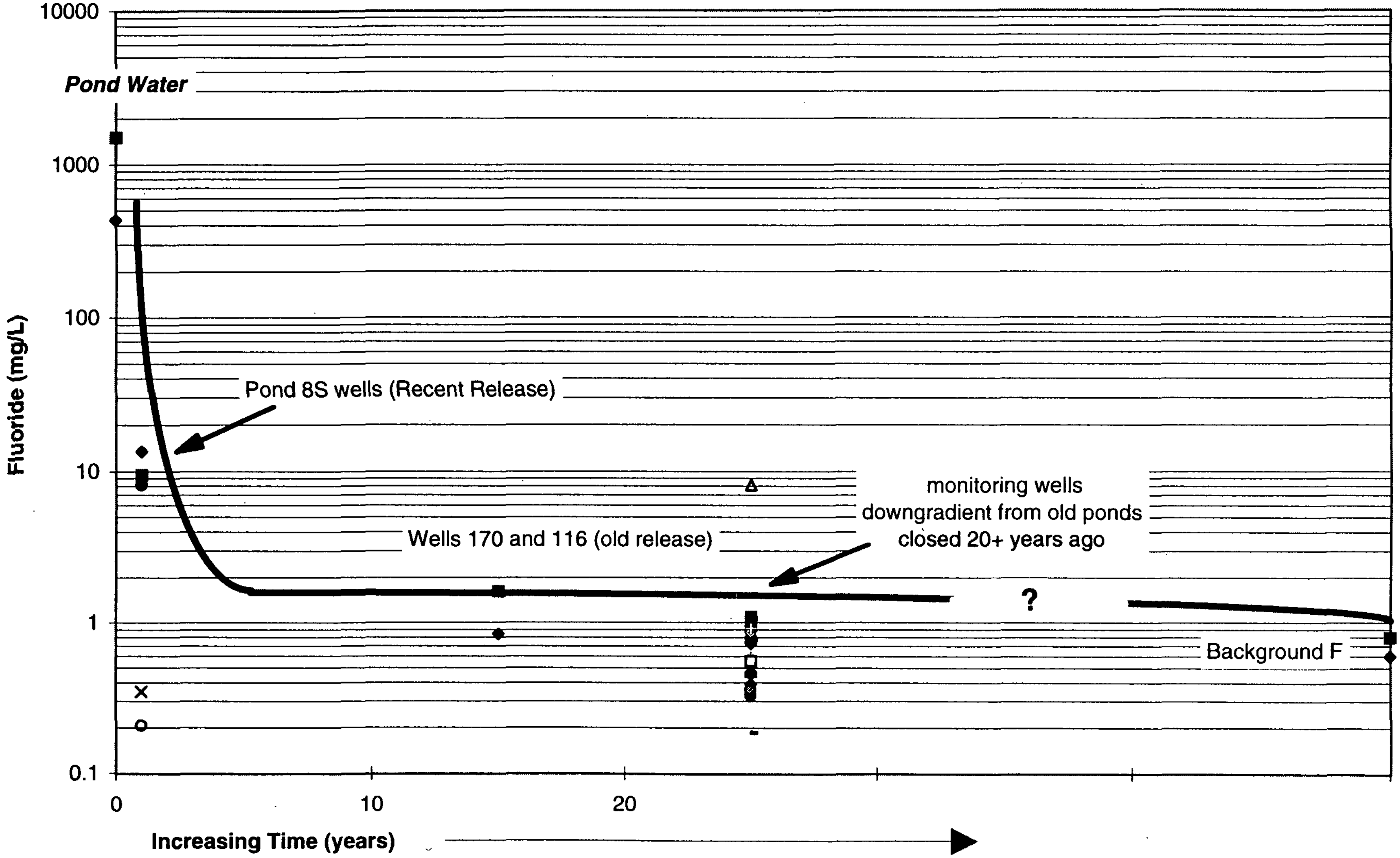
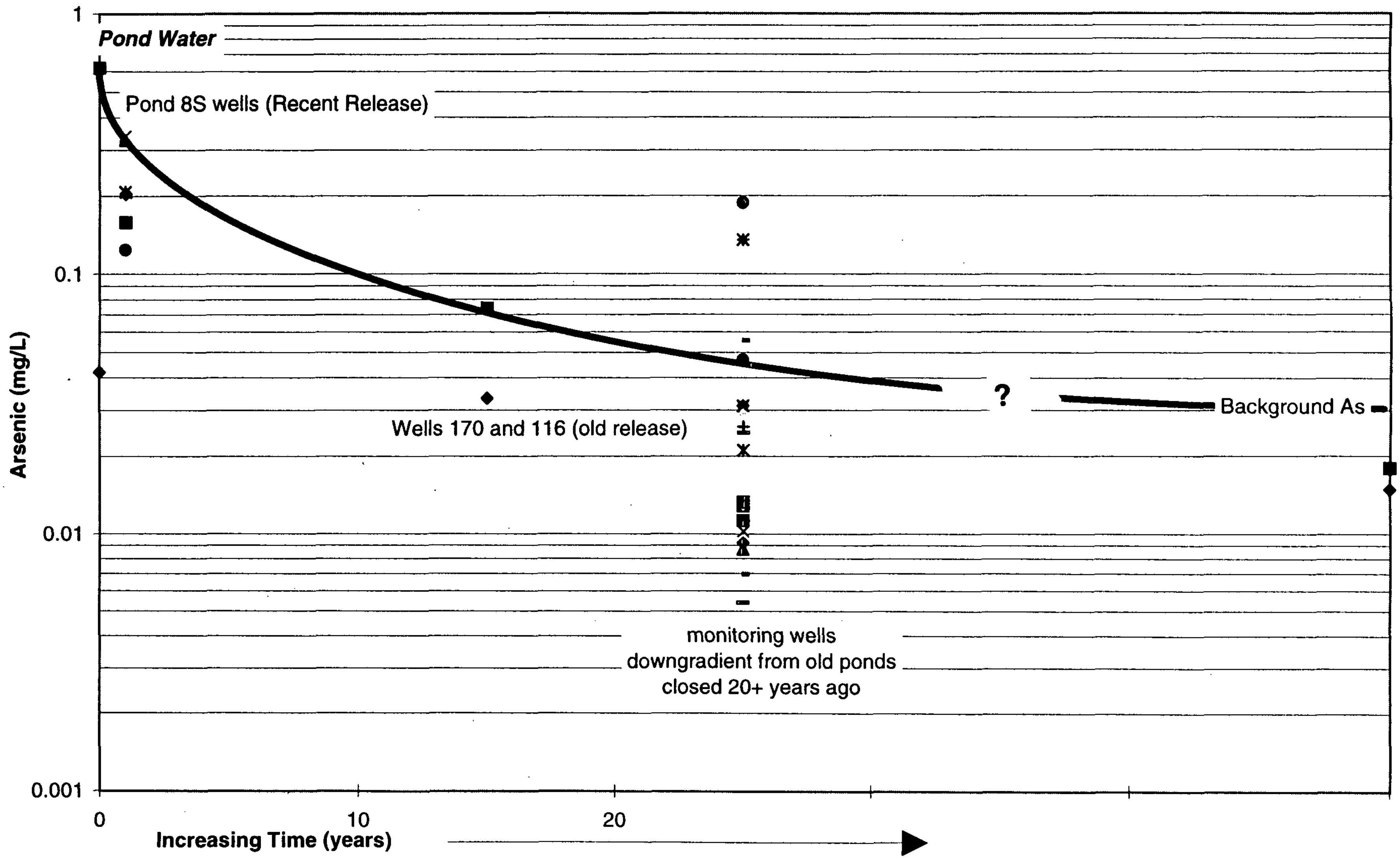


FIGURE 4
Arsenic Concentrations vs. Time (Approximated Decay Curve)



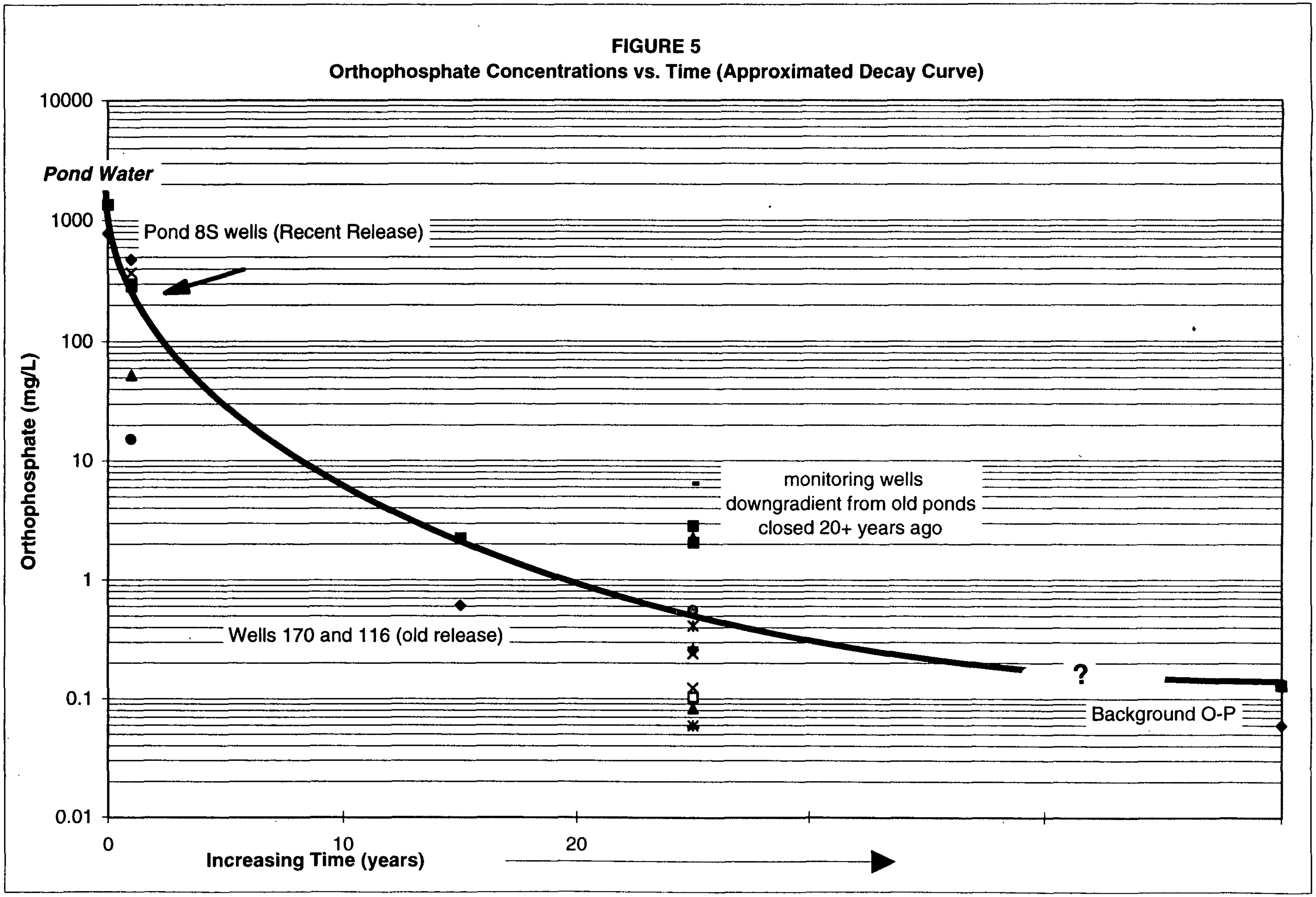
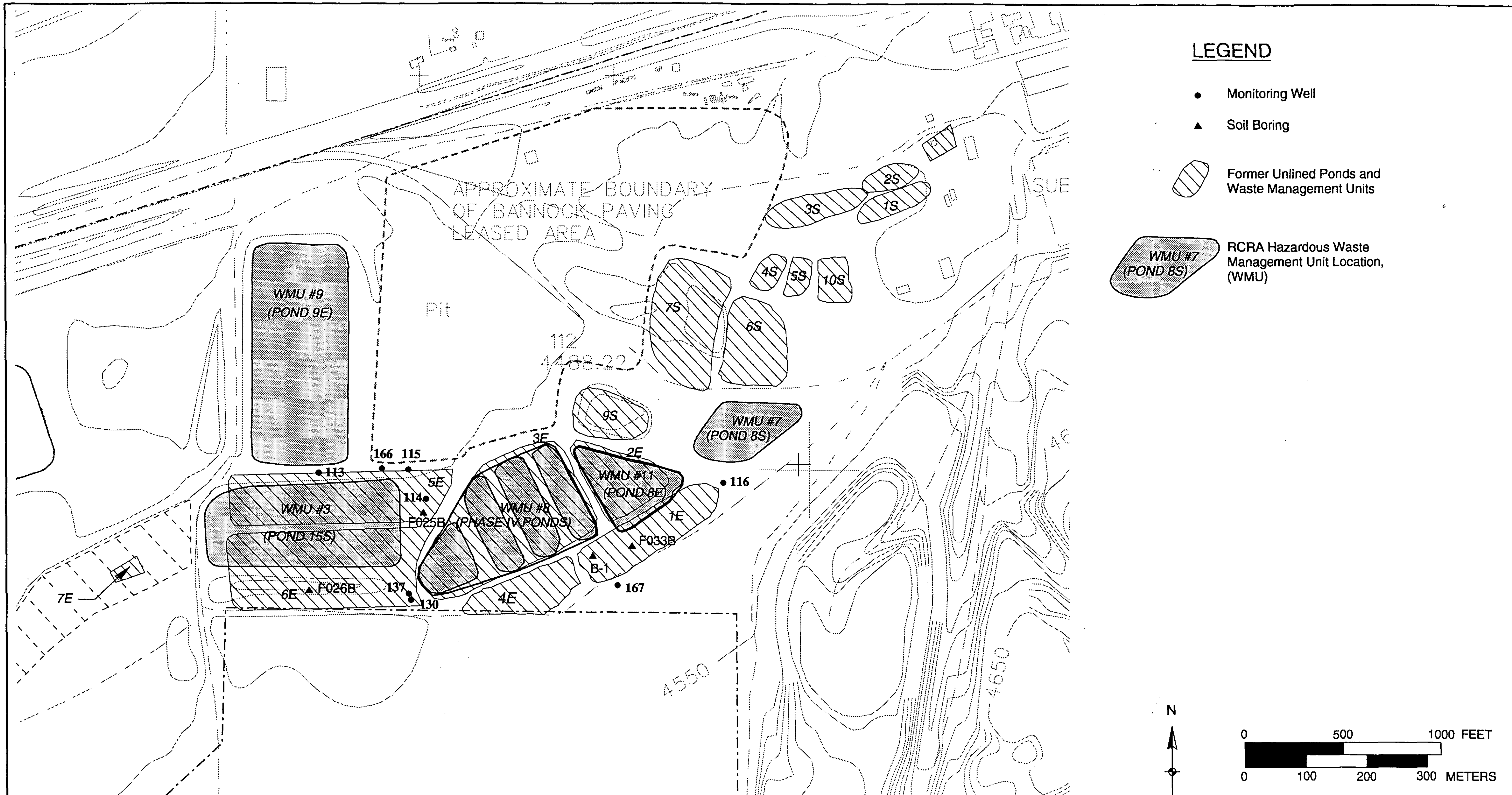


FIGURE 5
Orthophosphate Concentrations vs. Time (Approximated Decay Curve)
10000
1000
100
10
1
0.1
0.01
Orthophosphate (mg/L)
Pond Water
Pond 8S wells (Recent Release)
monitoring wells downgradient from old ponds closed 20+ years ago
Wells 170 and 116 (old release)
?
Background O-P
0
10
20
Increasing Time (years)

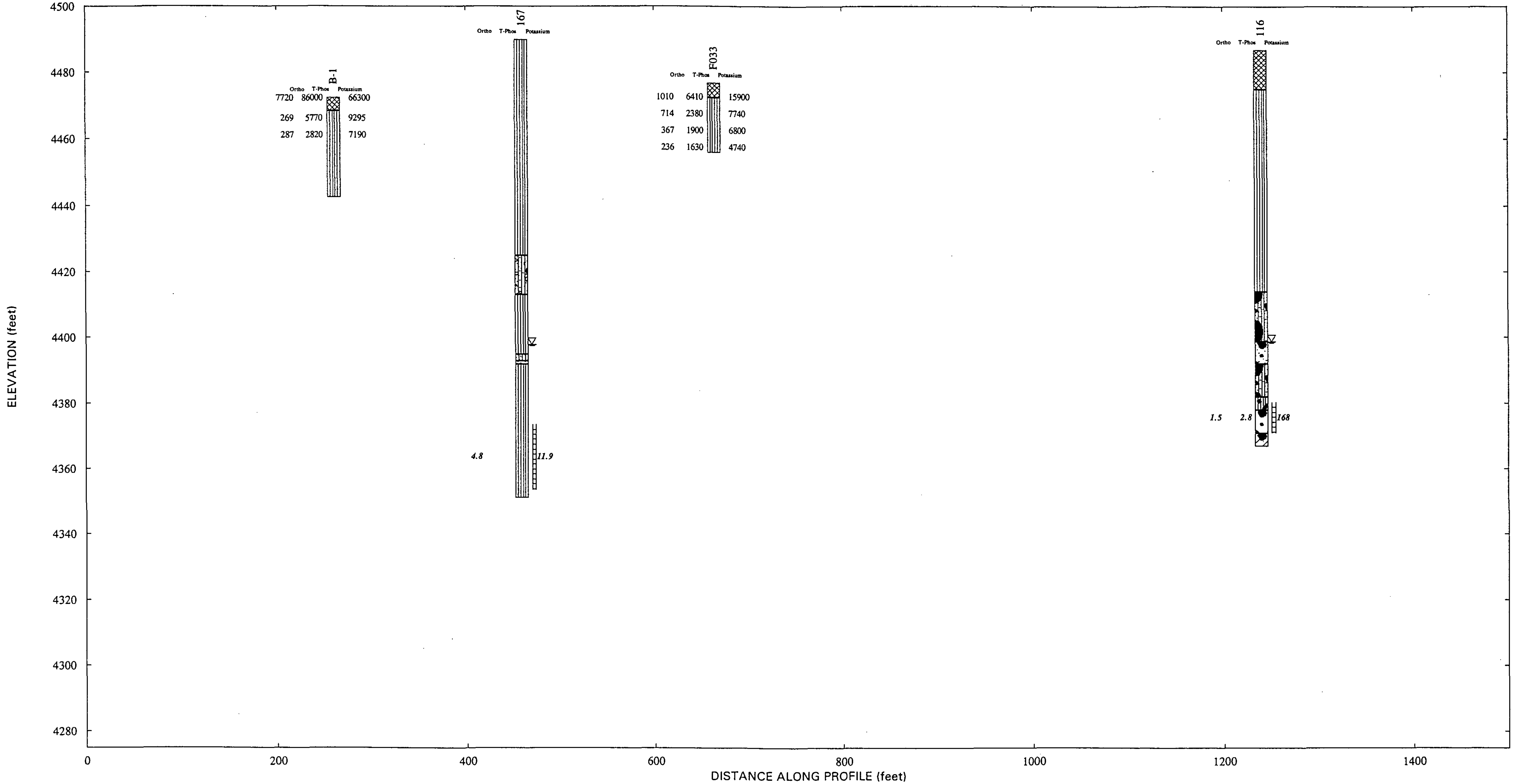


BECHTEL ENVIRONMENTAL, INC.
SAN FRANCISCO

FMC CORPORATION
POCATELLO, IDAHO

WELLS AND SOIL BORINGS ASSOCIATED WITH FORMER PONDS 1E, 5E, AND 6E

JOB No.	DRAWING No.	REV.
20906	FIGURE 6	



Explanation

- GRAVEL (GW), well-graded
- GRAVEL with SAND (GP)
- SILTY GRAVEL (GM)
- CLAYEY GRAVEL (GC)
- SILTY SAND with GRAVEL (SM)
- SAND with GRAVEL (SP)
- SAND (SW/SP)
- SAND to SILTY SAND (SP-SM)
- SILTY SAND (SM)
- CLAYEY SAND (SC)
- SILTY SAND with GRAVEL (SM-ML)
- SANDY SILT (ML)
- SILT (ML), low to medium plasticity
- SILT (MH), high plasticity
- SILT with GRAVEL (ML)
- SANDY CLAY with GRAVEL (CL)
- CLAY (CL), low to medium plasticity
- SILTY CLAY (CL)
- CLAYEY SILT (ML)
- PEAT (Pt)
- GRAVELLY SILT (GM)
- SANDY SILT (ML)
- FILL
- Weathered RHYOLITE
- Well Screen

Concentrations in Soil in (mg/kg)

Concentrations in Groundwater in (mg/L)

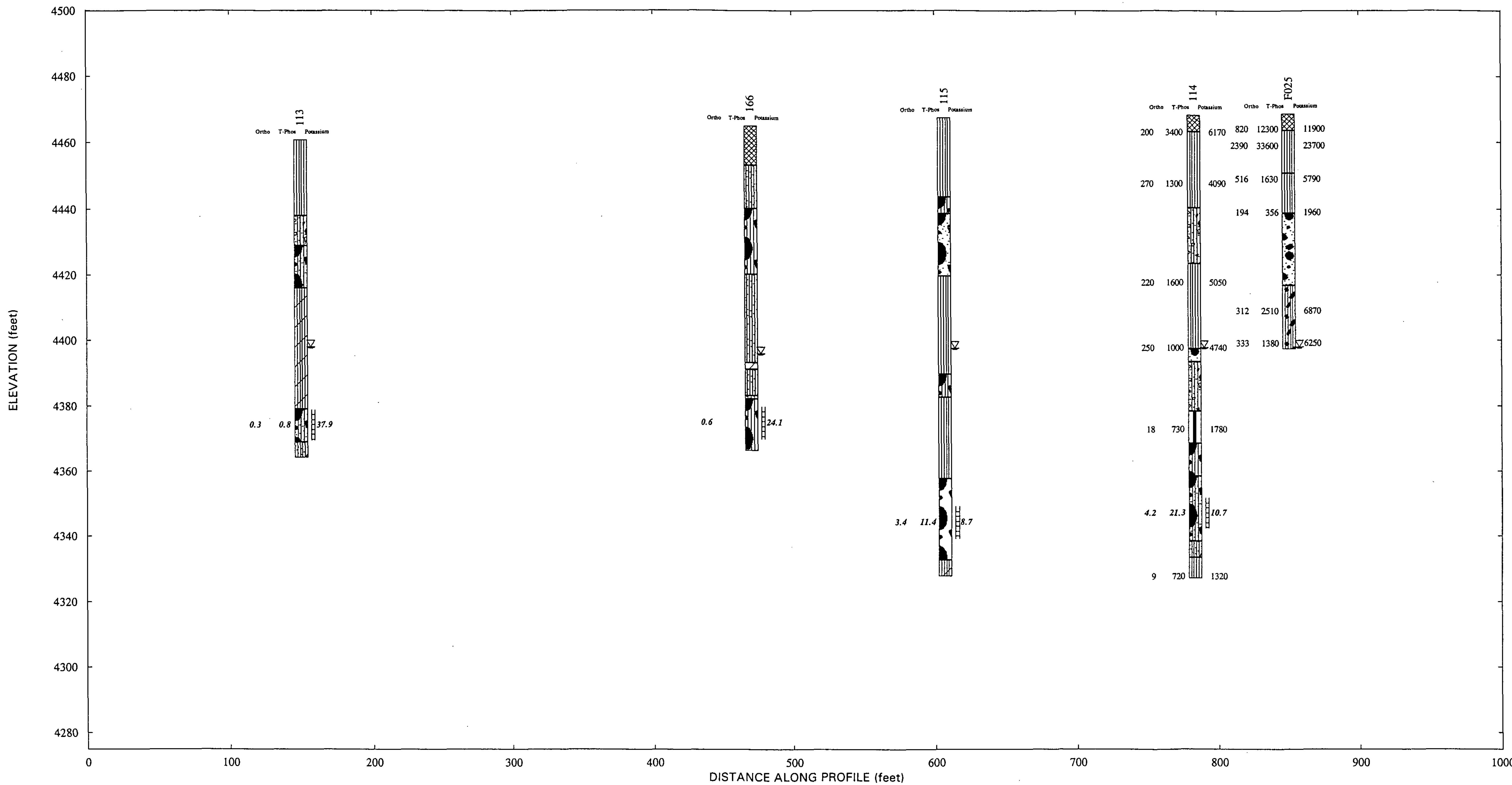
BECHTEL ENVIRONMENTAL, INC.
SAN FRANCISCO

FMC CORPORATION
POCATELLO, IDAHO

Pond 1E

JOB No.	DRAWING No.	REV
20906	7	

(Template: E17FMC1) (Text Overlay: FMC1E)



Explanation

GRAVEL (GW), well-graded	SAND with GRAVEL (SP)	SILTY SAND with GRAVEL (SM-ML)	SANDY CLAY with GRAVEL (CL)	GRAVELLY SILT (GM)
GRAVEL with SAND (GP)	SAND (SW/SP)	SANDY SILT (ML)	CLAY (CL), low to medium plasticity	SANDY SILT (ML)
SILTY GRAVEL (GM)	SAND to SILTY SAND (SP-SM)	SILT (ML), low to medium plasticity	SILTY CLAY (CL)	FILL
CLAYEY GRAVEL (GC)	SILTY SAND (SM)	SILT (MH), high plasticity	CLAYEY SILT (ML)	Weathered RHYOLITE
SILTY SAND with GRAVEL (SM)	CLAYEY SAND (SC)	SILT with GRAVEL (ML)	PEAT (Pt)	Well Screen

Concentrations in Soil in (mg/kg)

Concentrations in Groundwater in (mg/L)

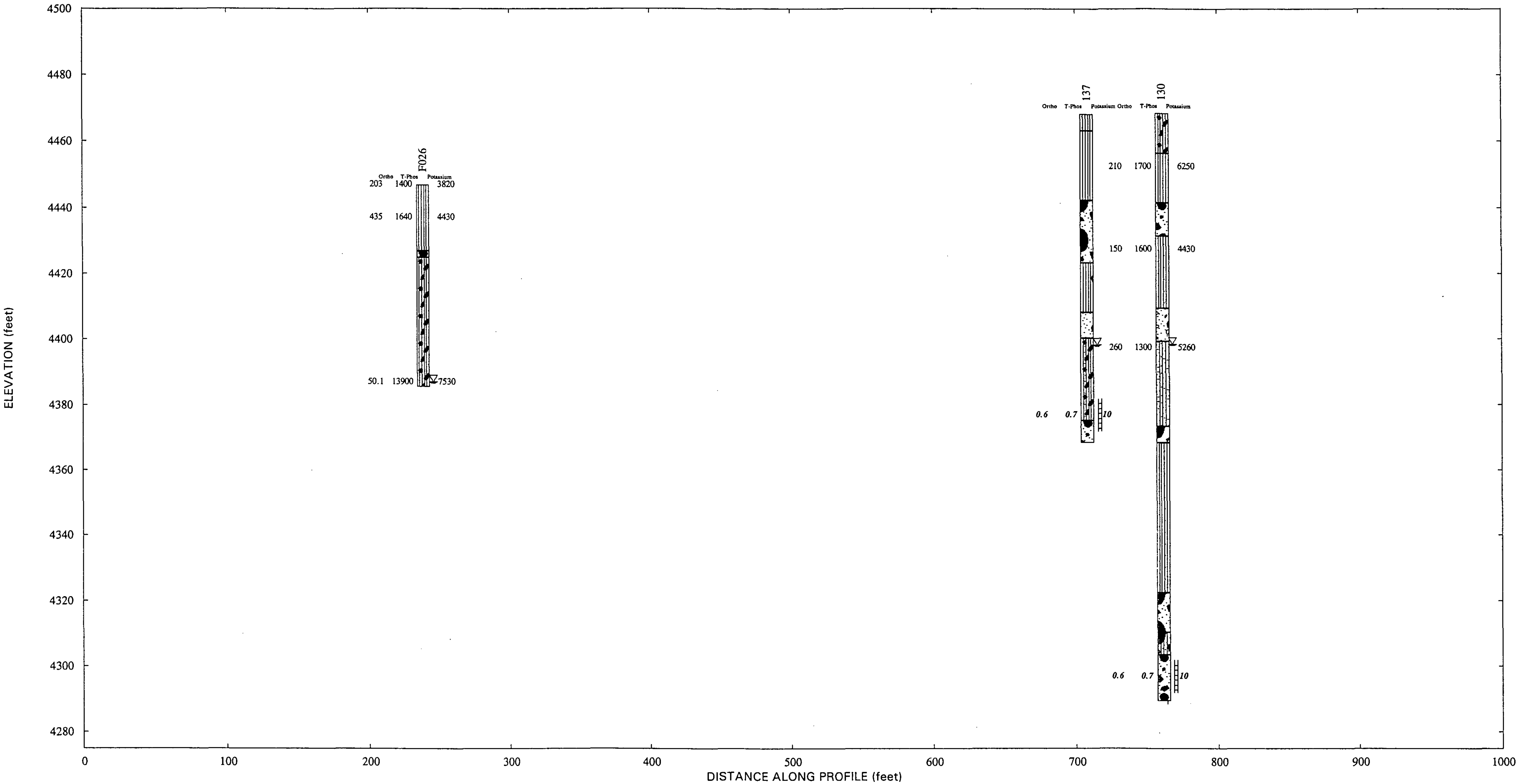
BECHTEL ENVIRONMENTAL, INC.
SAN FRANCISCO

FMC CORPORATION
POCATELLO, IDAHO

Pond 5E

JOB No.	DRAWING No.	REV
20906	8	

(Template: E17FMC1) (Text Overlay: FMC5E)



Explanation

- GRAVEL (GW), well-graded
- GRAVEL with SAND (GP)
- SILTY GRAVEL (GM)
- CLAYEY GRAVEL (GC)
- SILTY SAND with GRAVEL (SM)
- SAND with GRAVEL (SP)
- SAND (SW/SP)
- SAND to SILTY SAND (SP-SM)
- SILTY SAND (SM)
- CLAYEY SAND (SC)
- SILTY SAND with GRAVEL (SM-ML)
- SANDY SILT (ML)
- SILT (ML), low to medium plasticity
- SILT (MH), high plasticity
- SILT with GRAVEL (ML)
- SANDY CLAY with GRAVEL (CL)
- CLAY (CL), low to medium plasticity
- SILTY CLAY (CL)
- CLAYEY SILT (ML)
- PEAT (Pt)
- GRAVELLY SILT (GM)
- SANDY SILT (ML)
- FILL
- Weathered RHYOLITE
- Well Screen

Concentrations in Soil in (mg/kg)

Concentrations in Groundwater in (mg/L)

BECHTEL ENVIRONMENTAL, INC. SAN FRANCISCO		
FMC CORPORATION POCATELLO, IDAHO		
Pond 6E		
JOB No.	DRAWING No.	REV
20906	9	

(Template: E17FMC1) (Text Overlay: FMC6E)

Near the northeastern portion of the fenceline of the FMC Elemental Phosphorus Plant area, there is a naturally occurring low area between the UPRR railroad to the north of the plant and the ore handling area of the plant. This area, known as the "railroad swale" receives stormwater runoff from a portion of the plant (north side of ore handling and the phos dock). The railroad swale is a long, narrow depression about 30 feet wide and 1,000 feet long, with gently sloping sides over most of its length. At its western end, near the plant administration buildings, it is about 8 feet deep. However, the ground above the swale slopes downward to the east, and the swale is only about two feet deep at its eastern end. The storage volume is about 0.6 MG (2,300 cubic meters). The runoff volume from the maximum historic 24-hour storm was estimated to be 0.89 MG (3,400 cubic meters) and from a 24-hour 2-year storm runoff was estimated to be 0.44 MG (1,700 cubic meters) (Bechtel, 1995).

In November and December of 1993, the railroad swale was lined from the western end, where the storm drain enters the swale, for a distance of 330 feet. A trapezoidal channel was constructed with a 6-foot bottom width, 1.25-foot depth, 3:1 side slopes, and a channel slope of 0.8% (Hydrometrics, 1994). This channel has a 30 mil PVC liner, covered by a protective sand layer with a minimum thickness of 6 inches. The sand layer is topped with a 2-inch thick gravel layer. A secondary channel approximately 35 feet wide was created by sloped banks above and on either side of the primary channel.

Costs were developed to extend the lined channel for an additional distance of approximately 850 feet to the east. Cost data are provided in the following tables. Calculations used for development of the costs are provided in the calculation sheets which follow the tables.

Table 1
RAILROAD SWALE AREA
Extend Existing Liner

Item No.	Task	Quantity	Unit	Unit Cost	Total Cost
001	Mobilization and Demobilization (5%)	1	L. S.	$ 8,086.00	$ 8,086
002	Excavate Soil	645	cu. yd.	$ 11.51	$ 7,424
003	Grade swale to finish grade	315	cu. yd.	$ 9.30	$ 2,930
004	Install anchor trench	1,940	ln. ft..	$ 1.53	$ 2,968
005	Place liner subgrade	567	cu. yd.	$ 20.04	$ 11,363
006	Install 40 mil HDPE liner	36,493	sq. ft.	$ 0.86	$ 31,384
007	Place protective layer	150	cu. yd.	$ 18.67	$ 2,800
008	Riprap for culvert outlet	15	cu. yd.	$ 118.17	$ 1,773
009	Disposal of excavated soil	645	cu. yd.	$ 12.08	$ 7,792
	TOTAL (Rounded)				**$ 76,520**

FMC Subarea - Cost Data for Extending Existing Railroad Swale Liner

ITEM	CAPITAL COST, $	O&M COST $/YEAR	PRESENT WORTH COST, $
I. Install Liner			
Grade swale and place bedding	33,600		33,600
Install liner with soil cover	43,000		43,000
Subtotal	76,600		76,600
Remedial Design, Engineering Support, Procurement, and Construction Management (25%)	19,200		19,200
Subtotal	95,800		95,800
Contingency (25%)	24,000		24,000
TOTAL	**119,800**		**119,800**

Bechtel National, Inc.

CALCULATION COVER SHEET

PROJECT	JOB NO.	CALC NO.	SHEET
EMF	20906-007	C-101	1

SUBJECT	GROUP
Lining for RR swale	Remediation Engineering

CALCULATION STATUS DESIGNATION	PRELIMINARY	CONFIRMED	SUPERSEDED	VOIDED
	[x]	[ ]	[ ]	[ ]

COMPUTER PROGRAM / TYPE	SCP	MAINFRAME	PC	PROGRAM NO.	VERSION / RELEASE NO.
	[ ] YES [x] NO	[ ]	[ ]		

Assumptions:

1. Storage capacity of railroad swale is based on RI Section 3.2.2.3.
2. RI swale capacity is assumed to be existing in-place capacity of swale. Any fill in the area of the swale will require equal amount of excavation and material removal from the area.
3. Trapezoidal channel section is assumed for the swale to provide the basis for estimating quantities associated with lining the area. Actual work will involve only removal of excess material replaced by material required to prepare liner subgrade and ballast material for liner.
4. Approximately 300' of the swale is already lined with an acceptable liner system.
5. *Assumed culvert outlet protection at the beginning of the swale area is satisfactory installed.*
6. HDPE liner is to be used due to exposure to ultraviolet as it will be difficult to cover lining with soil in areas with steep slopes (Liner on steep sloped areas are assumed to be exposed).
7. Material removed from the swale area is not hazardous and is to be hauled and disposed of inside the plant area with a haul distance of 2000' maximum.

NO.	REASON FOR REVISION	TOTAL NO OF SHEETS	LAST SHEET NO.	BY	CHECKED	APPROVED / ACCEPTED	DATE
A	Cost estimate	3	3	RLN	JKR.	[illegible]	

RECORD OF REVISIONS

Bechtel National, Inc.

CALCULATION SHEET

PROJECT:	EMF
JOB NUMBER:	20906-007
CALC NO.	C-101
SHEET NO.	2
SHEET REV.	A

SUBJECT: Railroad Swale Lining Estimate

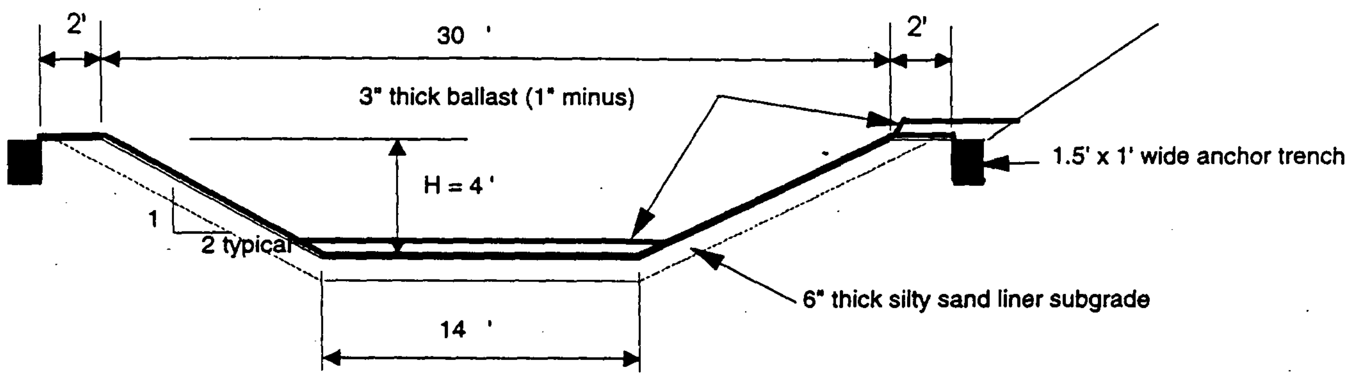
BY: Robert Ng DATE 1/20/97

Length of unlined swale = 850 ft. scaled from topo map; Length of total swale 1,150 ft.

Storage volume required in RI (Section 3.2.2.3) = 0.6 million gallons or 80,214 cu. ft.

Assuming a typical trapezoidal section with a top width 30 ft (approximated from topo map):

using a 2 horizontal to 1 vertical side slopes, average depth is



Average cross section area required A = 80,214 / 1,150 = 70 sq. ft. per ft. of swale

A = (30 -2x(H-3")) x (H-3") = 30(H-3") -2(H-3")^2 = 30H - 7.5 - 2H^2 - 0.1 = 70

30H - 2H^2 = 77.13 ; H = (-b - (b^2-4ac)$^{1/2}$)/2a = 3.3 ft. say 4 ft. including freeboard.

Use 40 mil HDPE liner (due to ultraviolet exposure on slope areas) :

HDPE liner = (2x(2+1.5+1)+2x(22+1)1/2xH+14) plus 5% = 43 ft/ft or 36,493 sq. ft.

Earthwork:

Excavation (disposed off inside plant area within haul distance of 2000') of material to accommodate liner subgrade and ballast)

Volume = (3" x 14' + 6" x 34') x 850' = 17,425 cu. ft. or 645 cu. yds.

Grading of swale bottom cut to fill (assume smoothing operation for swale cross section required 10% of average cross section area or approximately 10 sq. ft.)

Excavation = Fill = 10 x 850 ' = 8,500 sq. ft. or 315 cu. yds.

Ballast (1" minus crushed slag)

Volume = ((14' + 5') x 3") x 850' = 4,038 sq. ft. or 150 cu. yds.

Liner subgrade (silty sand from borrow sand pit)

Volume = (36' x 6") x 850 = 15,300 sq. ft. or 567 cu. yds.

Anchor Trench = (850' x 2 + 40' x 6) = 1,940 linear ft.

Bechtel National, Inc.

CALCULATION SHEET

PROJECT:	EMF
JOB NUMBER:	20906-007
CALC NO.	C-101
SHEET NO.	3
SHEET REV.	A

SUBJECT: Railroad Swale Lining Estimate

BY: Robert Ng DATE 1/20/97

SUMMARY : OPTION 1 (ASSUMING 300' OF EXISTING LINING IS ACCEPTABLE)

Liner: HDPE-40mil	36,493	SF
Earthwork:		
Excavation and disposal inside plant area with max. 2,000' haul	645	CY
Grading of swale cut to fill Excavation = Fill =	315	CY
Ballast (1" minus crushed slag)	150	CY
Liner subgrade (borrowed sand)	567	CY
Anchor Trench (1' wide x 1.5' deep)	1,940	LF